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TECHNOLOGY UTILIZATION/COMMERCIALIZATION ACTIVITIES AT ARGONNE NATIONAL LABORATORY

by

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Technology Transfer Office

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"In order to penetrate even further into their subjects, the host of specialists narrow their fields and dig deeper and deeper till they can't see each other from hole to hole. But the treasures their toil brings to light they place on the ground above. A different kind of specialist should be sitting there, the only one still missing. He would not go down any hole, but would stay on top and piece all the different facts together."

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DEFINITIONS

Technology Item -- any invention, discovery, improvement, innovation, or other item . . . whether or not patentable . . . Technology items include, but are not limited to, new or improved techniques, products, devices, materials, processes, systems, machines, apparatus, fixtures, tools, instruments, and computer programs.

Technology Commercialization -- the process by which Federal R&D results are transferred to the private sector and become available to the consumer in the marketplace at a price he is willing to pay.

Technology Transfer -- the process by which technology developed for one field of application is introduced to another field for application.

Technology Utilization -- the process by which existing knowledge from research is translated operationally into useful processes, products or programs which fulfill actual or potential public or private needs.

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ABSTRACT

Technology utilization/commercialization is the process of applying technology to satisfy a preexisting need. The present report examines the organizational relationships involved, the controlling factors, and the role of the technology agent. Included is a brief assessment of the technology commercialization activities currently under way as part of specific research and development projects at Argonne National Laboratory. In addition to the usual supporting references, an Appendix is devoted to a sampling of the relevant literature.

INTRODUCTION

The thirty-year history of the Argonne National Laboratory (ANL) and its predecessor, the Metallurgy Laboratory at the University of Chicago, is gorged with examples of technologies conceived and nurtured in the Laboratory and delivered to commercial application by industry. During the early years of sponsorship by the U. S. Atomic Energy Commission, little thought was given to the many formal and informal interactive mechanisms linking ANL with industry -- these relationships were clearly necessary to accomplishing the mission and so everyone just got on with the job. Later it was seen that significant "spin-off" benefits might accrue if the technologies developed for nuclear applications could be brought to bear in other areas. The terms technology transfer and technology utilization were adopted to describe, and to some extent formalize, what had been occurring for a long time.

More recently, the Federal government, responding to a renewed awareness of the importance of the supply of energy available in the United States, began to move to consolidate energy-related research and development (R&D) under a single agency. In anticipation of this new legislation, ANL began broadening its activities into many energy-related areas. During this period, it was recognized that, as new areas of energy R&D were introduced into the ANL program, a need would develop to work with industrial sectors and individual companies that had no previous tradition of cooperative development involving a National Laboratory. Then, on January 19, 1975, the Energy Research and Development Administration (ERDA) came into existence charged with the responsibility for speeding emerging energy-related technology items, as opposed to transferring existing technology items, into the marketplace. This unique mission is often referred to as "technology commercialization."

This Laboratory, as well as others, responded quickly and positively to these changes because, as the Laboratory Director recently stated,[1] ". . . the scientist-as-hero image from which the Laboratory gained its great momentum in the early post-World War II years has now all but faded completely away. More than ever before we must provide convincing evidence that we can contribute importantly, creatively and innovatively to the solution of the energy and environmental problems facing the nation." Therefore, evolving and carrying out aggressive strategies to involve industry in energy-related R&D at an early stage have been incorporated into the proposals and work plans of individual ANL projects.

Since technology commercialization is now firmly established as a necessary and desirable facet of the energy-related programmatic efforts of the Laboratory, it is appropriate to examine the technology utilization/commercialization (TU/C) process and the current level of ANL expertise in technology commercialization activities.

THE TECHNOLOGY UTILIZATION/COMMERCIALIZATION PROCESS

The TU/C process can be described as the process by which a need can be satisfied through the application of technology in response to the identification of that need. Figure 1 is a deceptively simple representation of the process from beginning to end. The indication of the flow of time is included to underscore the idea that commercialization of technology is not an event but is a process.

The specific time interval involved is a direct function of the maturity of the technology item that is being commercialized. According to a recent NBS report,[2] an average of 7.2 years was required to commercialize a technology item during the 1967 to 1973 interval. Whatever the absolute value, it is during this period that a technology item matures from theory to commercial applicability through a series of stages as shown in Fig. 2.

In general, the stages of technology item maturation follow one another in the sequence shown and only occasionally is a particular stage leapfrogged successfully. More importantly, it is critical that the maturity of a technology item that has commercialization potential be judged accurately. Otherwise the overall strategy and the specific tactics employed in the TU/C activity may be inappropriate.

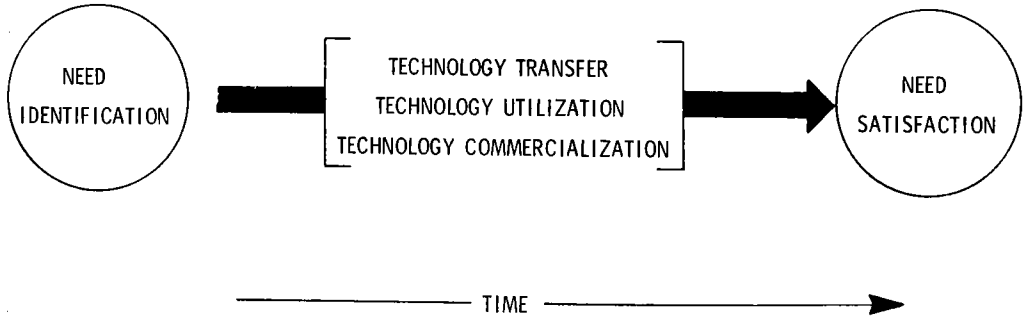

Fig. 1. This Is What It Is All About. Neg. No. MSD-63293.

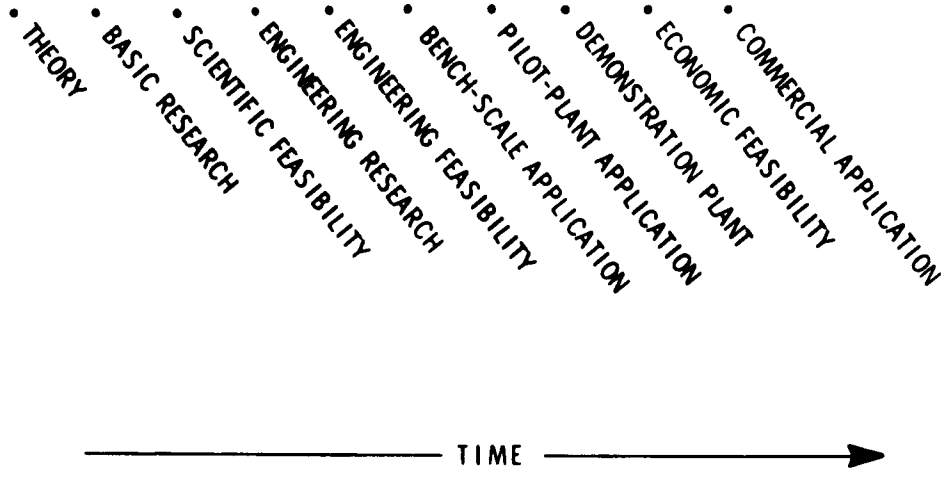

Fig. 2. Stages in the Maturation of a Technology Item.
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The importance of the maturity of the particular technology item may be best illustrated by considering the share of the TU/C burden borne by the R&D source at various stages. This burden represents the totality of an organization's commitment to commercialization in terms of both tangibles and intangibles, i.e., dollars, personnel, facilities, middle and top management support, organizational and individual attitudes, and perceptions of risk vs benefit. As can be seen, the share of the TU/C burden becomes less and less, relative to the share borne by supplier organizations, as maturation progresses, which is shown schematically in Fig. 3.

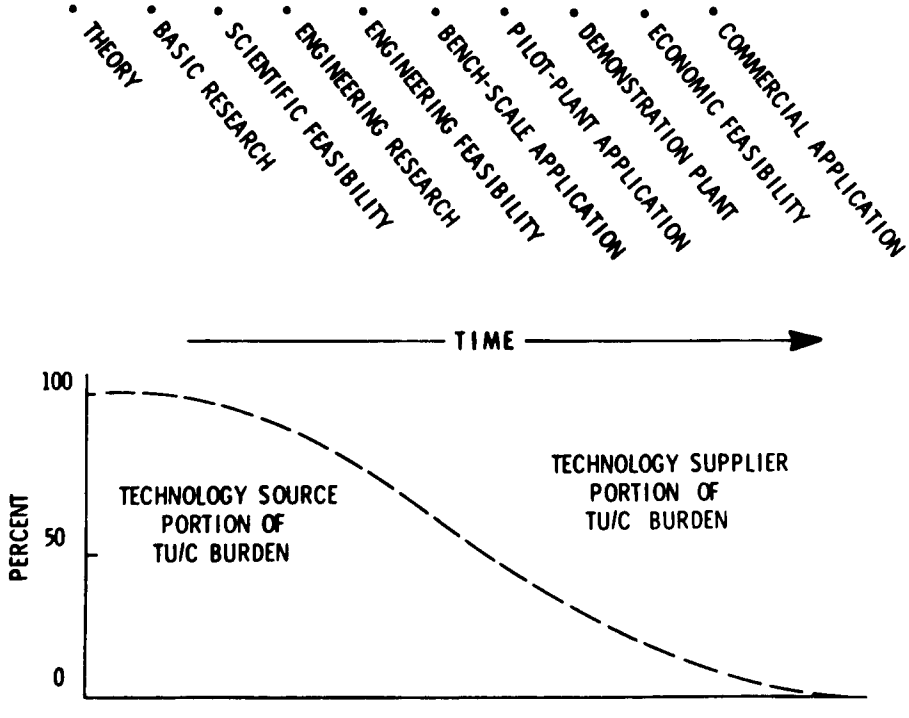

Fig. 3. Source/Supplier Share of TU/C Burden.
Neg. No. MSD-63290.

Technology suppliers are most easily described as those organizations that adopt and subsequently deliver to the marketplace technology items in the form of a product, process, or service. Suppliers are generally individual companies that, no matter what product or service they provide, have the common characteristic of surviving by meeting the needs of their customers at a profit.

These customers or technology users, as they will be referred to hereafter, play a determining role in the process. Users, depending upon the specific technology item involved, may be governmental bodies or agencies, particular companies, or even individual consumers. Despite this diversity of possibilities in describing users, they also share a common characteristic -- an accurate identification of need (and the operational and economic criteria for the satisfaction of that need) can be obtained only from the potential users.

TU/C involves, in addition to the R&D activities directed toward advancing the maturity of the technology, complex interactions among source, supplier, and user. These interactions are rooted in dialog between one human being and another. The importance of these interpersonal relationships cannot be overemphasized.

Traditionally,[3] the sources of technology disseminated information relative to R&D programs through, for example, publications in scientific and engineering journals, papers read at professional society meetings, and staff participation in seminars. Supplier organizations cultivated at least some degree of awareness of the progress of these programs and, based on their perception of the potential market, introduced new goods and services to their catalogs.

As can be seen in Fig. 4, the traditional approach to commercialization suffers two shortcomings. The users are forced to rely on the suppliers for satisfaction of their needs, since the users have no communications link to the sources of technology. Given a need, the user must search from supplier to supplier for the technology item. In addition, the traditional approach includes no deliberate or systematic feedback linkages from the suppliers to the sources.

The shortcomings of the traditional approach can be overcome by an aggressive TU/C activity designed to exploit knowledge of how the process works. The key to an effective TU/C effort is in charging specific

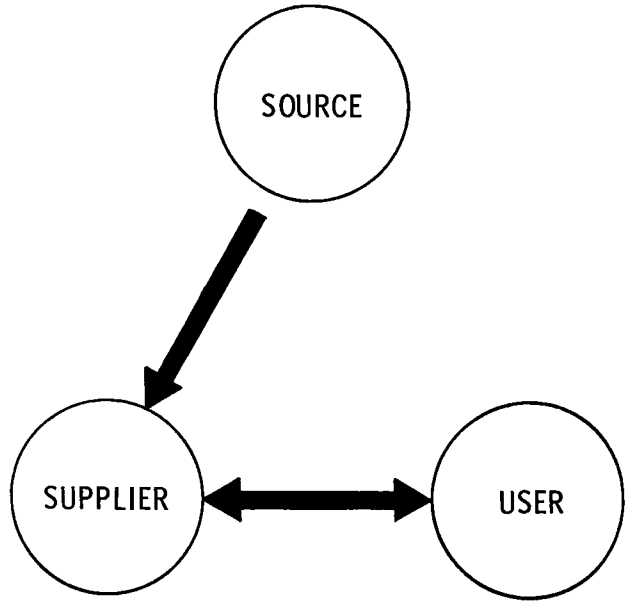

Fig. 4. Traditional Approach to TU/C. Neg. No. MSD-63292.

individuals with the full-time responsibility for planning and executing this effort.[4] These individuals can be designated "commercialization agents." These commercialization agents serve as the contact point to catalyze and accelerate the movement of a particular technology item from laboratory to marketplace. Thus, the commercialization agent is uniquely situated and motivated to perform certain "preparatory exercises" that are critical to the elimination of the shortcomings of the traditional process for commercialization of a technology item.

These preparatory exercises may include the creation of source and supplier awareness of a user need and/or supplier and user awareness of a potential for need satisfaction. The commercialization agent becomes involved with users, suppliers, and sources in analyzing and defining both need and potential solution to the satisfaction of all parties. These preparatory exercises require that the commercialization agent circulate freely among source, supplier, and user. In so doing, he becomes the catalyst that initiates and services two-way communication linkages among all parties. These linkages are ideally based on face-to-face interactions through which users, suppliers, and sources become aware of one another's capabilities and specific interests. Given these linkages, as shown in Fig. 5, and a technology item of mutual interest, the TU/C process can be said to have begun.

The process, once initiated, will hopefully proceed to completion, at which time a user may purchase the technology item "in the marketplace and use it in *his* operations to satisfy *his* goals and objectives."[5]

It should be noted that no fundamental rule of individual or organizational behavior exists that requires the commercialization agent be completely decoupled from personal involvement in the R&D on a particular technology team. Assuming the necessary user/supplier empathy, communication skills, personal motivations, and freedom from the Not Invented Here (NIH) syndrome, the commercialization agent could be located almost anywhere in a supplier, user, or source organization. The degree to which the agent is successful will depend, no matter where he is located, upon his attention to manipulating and accelerating the process, the skill with which he selects and executes specific tactics and strategies, and the amount of support available to clear internal and external organizational barriers.

Irrespective of specific organizational affiliation and location of the commercialization agent, his task has barely begun when the conditions of Fig. 5 have been satisfied. To progress from need identification

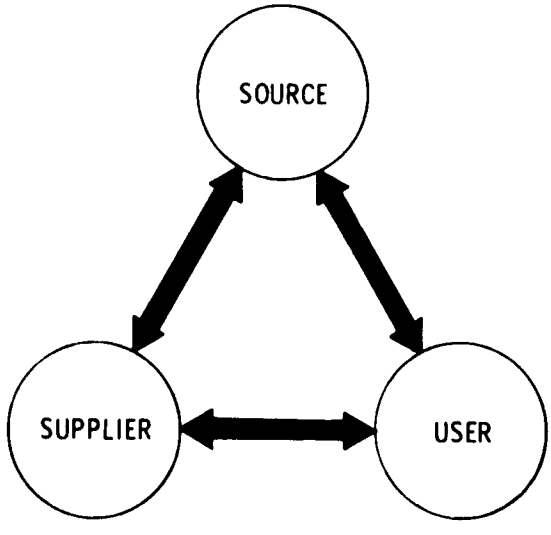

Fig. 5. Given a Mutually Acceptable Definition of Need, the TU/C Process Can Now Be Said to Have Begun. Neg. No. MSD-63291.

to need satisfaction, the technology item of concern must go through the stages of maturity discussed earlier. During a roughly parallel time frame, potential suppliers must become actively involved in technology-item adoption.

Technology-item adoption is a process that has a number of overlapping, yet distinctive stages, as seen in Fig. 6. Several of these stages are subject to influence by the commercialization agent, i.e., information gathering, organizational awareness, decision-maker awareness, recognition of need satisfaction potential, and adoption decision. A positive influence on any of these should serve to accelerate the adoption process. However, two of these stages, from the commercialization agent's point of view, are intimately related and controlling.

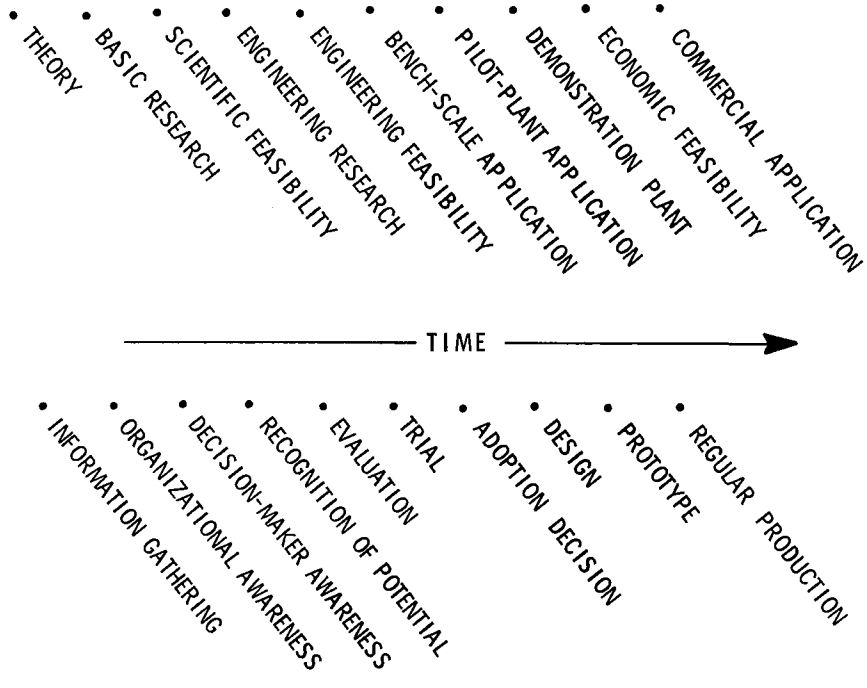

Fig. 6. Adoption Process Stages and Maturity for a Technology Item. Neg. No. MSD-63287.

To state the case quite bluntly, commercialization will not occur until a decision-maker in a supplier organization becomes aware of a technology item with a need satisfaction potential and unless that decision-maker commits his company to adoption and delivery to the market of the technology item. Therefore, once the linkages among source, supplier, and user have been established, every action of the commercialization agent must be weighed according to its impact in influencing the decision-maker and the adoption decision.

The adoption decision represents a firm and significant commitment of resources on the part of the supplier and, therefore, is not arrived at casually. This decision is made up of several elements, some representing tangible quantities and some reflecting opinions or behavior patterns. Figure 7 is a nonranked listing of these elements. For any given supplier organization, other elements may be present, and the relative weight assigned each element will be specific to that company or decision-maker.

RECOGNITION OF NEED SATISFACTION POTENTIAL

COMPATIBILITY WITH PRESENT & FUTURE PRODUCT LINE

COMPATIBILITY WITH TECHNICAL & MANUFACTURING CAPABILITIES OF FIRM

DESIGN ENGINEERING COSTS

PRODUCTION DEVELOPMENT COSTS

CAPITAL INVESTMENT REQUIREMENTS

MARKET DEVELOPMENT COSTS

PROFIT POTENTIAL

INDIVIDUAL & FIRM RISK-TAKING BEHAVIOR

Fig. 7. Elements of the Adoption Decision. Neg. No. MSD-63289.

An examination of the elements of the adoption decision shows that, through the commercialization agent, several are subject to some degree of predetermination or to influence by deliberately tailoring information to meet the needs of the decision-maker. The foregoing statement could be interpreted as invoking "the policy of maximum unfairness"[6] or a suggestion that data on financial risk/benefit be doctored. Neither is intended. It is intended, however, to emphasize that the commercialization agent should assume an active role with respect to supplier companies and their decision-makers.

Recognition of need satisfaction potential is an adoption decision element that is particularly suited to influence by the commercialization agent. This person is initially in an ideal position to develop a clear understanding of the user need and, at the same time, to assess the likelihood that a given technology item will satisfy the need. The commercialization agent may then begin the identification of potential suppliers and the individual decision-makers in these firms. These decision-makers must recognize the potential for need satisfaction.

The identification of potential supplier firms is a screening process that, at least to some degree, can be initiated by the commercialization agent. The characteristics of a particular technology item will require that supplier companies have a fairly specific set of technological and manufacturing capabilities. Supplier companies that lack these capabilities are not likely to succeed in delivering the technology item to the marketplace.

In a similar manner, companies that are marketing a product for which the new technology item may provide competition are not likely to vigorously pursue commercialization. This same lack of enthusiasm might reasonably be expected from a company that has made significant commitments to a future product, process, or service which is threatened by the new technology.

The last of the adoption decision elements subject to some degree of preselection is the risk-taking behavior of a firm as well as the individual decision-maker. Initial assessments of risk-taking behavior obviously require the exercise of considerable judgment on the part of the commercialization agent. However, the company's past record of innovation and the apparent motivations of its top management may provide insight on future behavior.

The remainder of the adoption decision elements involve out-of-pocket costs and capital investment requirements weighed against profit potential. Clearly these cannot be predetermined nor controlled by the commercialization agent. However, these elements often represent large commitments on the part of the supplier. The importance of these considerations and the weight they carry in the deliberations of the decision-maker must be clearly recognized and acknowledged by the commercialization agent. Moreover, he should exploit every possible opportunity to provide, directly to the decision-maker, concise information related to these financial requirements. Two important benefits to the commercialization activity will result from this tailoring and targeting. First, the decision-maker must have this key information, and he will be grateful if it is in a form uncluttered with technical detail. Second, in providing tailored, targeted information, the commercialization agent establishes credibility as a business-oriented professional. Last, but certainly not least, is the matter of profit potential. The commercialization agent is not expected to discuss payback period, net present value, or rate of return on investment. These are largely a function of the internal accounting system in a particular firm. However, it is expected that the agent understand in considerable detail who the users are, the number of users, and how much they are willing to pay to satisfy their need. This type of information is only available through a formal or informal market survey. Without these data, it will be difficult to convince the decision-maker that a real need-satisfaction potential exists which represents an opportunity for his company.

Having shown that TU/C is a process (not an event) and the process can be charted, understood, and manipulated to some extent, let us examine the state of the art as currently practiced at ANL.

CURRENT STATE OF THE ART AT ANL

In view of the relatively short time interval since the Energy Research and Development Administration came into being, TU/C activities within the project organizations at ANL are alive and reasonably healthy. Evidence to support this conclusion is found in the attitudes of project personnel with regard to the importance of identifying and responding to the real needs that their technological developments must satisfy. Additional evidence of potential for TU/C activity success is found in the importance attached to influencing the adopt/reject decision through direct contact with the industrial decision-maker. For example, in many cases these individual decision-makers have been carefully characterized and, in some cases, listed.

Careful and thoughtful cultivation of interpersonal relationships with representatives of the industrial community and the encouragement of these representatives to visit the projects and the Laboratory are two TU/C tactics that are universally accepted and practiced. Similarly, an increasing emphasis has been placed on entering into contracts that involve joint or cooperative R&D and/or industrial participants.

Perhaps most significant is the observation that private organizations are cautiously and slowly showing an increased willingness to share R&D risks with the Laboratory.

These general conclusions are the result of numerous, detailed interviews with the ANL scientific, engineering, and support staff. These individuals comprised a carefully selected group that had experience in the practice of commercialization, responsibilities for the commercialization of specific technology items, or responsibilities in support of technology development projects which have shown, or are almost certain to show, significant progress in commercialization.

Table I lists specific tactics that may be employed to further or support commercialization of ANL technology items. The list has been ranked in descending order of value to commercialization, as perceived by the scientific, engineering, and support staff interviewed.

TABLE I. Tactics Ranked in Descending Order of Perceived Value to TU/C

Rank	Tactic
1	Interpersonal Relationships
2	Laboratory Visits
3	Information-exchange Meetings
4	State-of-the-art Reports
5	User Employee at ANL (Industrial Participant)
6	Cooperative R&D Programs
7	Industrial Consultants
8	Market Studies
9	ANL Employees as Consultants
10	Special Information Packages
11	User Groups (e.g., ZGS, EBR-II, SPKSY)
12	ANL Subcontracts (Industrial R&D)
13	Workshops
14	Bidder Meetings
15	ANL Procurement Contracts (Hardware)
16	Engineering Design Packages
17	Engineering Papers and Journal Publications
18	Popular and Semitechnical Magazine Articles
19	Reimbursable Contracts
20	Advisory Committees
21	Press Releases
22	University Consultants
23	Project Reports
24	Trade Journal Articles
25	ANL Employee Loan to Supplier/User
26	Project Newsletter
27	Peer Evaluations
28	Scientific Papers and Journal Publications
29	ANL Subcontracts (University R&D)
30	Exhibits and Trade Shows
31	Seminars (Scientific)
32	Training Courses
33	Tech Briefs

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3. This discussion of the traditional technology commercialization process and key ideas on "preparatory exercises" are based on ideas expressed by R. C. Maninger, Lawrence Livermore Laboratory, private communication (December 1975).

4. See, for example:
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6. W. C. Marshall, "Science and Industry: The Private Sector. Interaction Between Government Laboratories and Industry: Lessons from Harwell's Experience," *Proc. Natl. Acad. Sci.* 71(6), 2580-2583 (June 1974).

APPENDIX

To Dig Deeper

A considerable body of literature exists that is devoted to technology transfer, technology commercialization, technology utilization, and "spinoff." Some of the material is worth the time of either the casual student or the serious practitioner of these arts.

A sampling of the TU/C literature is included for the convenience of those who may wish to browse. Items keyed with an asterisk are particularly lucid discussions of the underlying principles and/or the economic, political, and societal needs that argue for increased attention to formalized efforts.

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